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FIRST RECORDS OF INVASION BY THE MYRMICINE JAPANESE ANT *VOLLENHOVIA EMERYI* W. M. WHEELER (HYMENOPTERA: FORMICIDAE) IN THE UNITED STATES

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Abstract.—*Vollenhovia emeryi* W. M. Wheeler was found at two sites over 2 yr in the Dyke Marsh Preserve, part of the George Washington Memorial Parkway, a National Park in Fairfax County, Virginia. This ant was also found at two locations along the shore of the Potomac River in Maryland: Fort Washington National Park, Prince George's County, and Glen Echo Park, Montgomery County. These are the first records for their respective states. A live colony of *V. emeryi* was collected from the campus of Georgetown University in the District of Columbia and is maintained at the Smithsonian Institution. Previous records for this ant in the United States are: Rock Creek Park, a National Park in the District of Columbia (1986), and Philadelphia, Pennsylvania (1993). These records indicate that this species has spread beyond areas of its initial introduction. This ant species may have entered the U.S. with imported Japanese cherry trees in the District of Columbia, and Philadelphia, Pennsylvania.

Key Words: *Vollenhovia emeryi* W. M.Wheeler, introduced species, alien, Japanese ant

Introduced ant species are some of the more destructive and expensive pests in the U.S. as well as worldwide (Crowell 1968, Porter and Savignano 1990, Cole et al. 1992, Morrison 2002, Breton et al. 2003, Hill et al. 2003). However, the majority of ant species are not likely to be introduced through human activities because of habitat preferences and specialization on specific prey. Alien, invasive ant species tend to be habitat and prey generalists, often with polygynous colonies, and with nesting habits that increase their likelihood of transportation through human trade (Holway et al. 2002).

Linepithima humile (Mayr) (Argentine ant), an aggressive alien ant introduced into southern California and Louisiana from South America in the 1890s, is rapidly spreading into most of the southwestern U.S. (Cole et al. 1992, Holway 1998). *Solenopsis invicta* Buren (red imported fire ant) is one of the more notorious alien invasives in the U.S. (Porter and Savignano 1990). This ant spread rapidly after its introduction in Mobile, Alabama, during the 1930s and its range extends through most of the southern U.S. *Solenopsis invicta* quickly decimated local arthropod populations and has caused human injuries and

deaths due to its venomous sting. Recently, and for reasons yet unknown, this ant appears to be declining behind its invasion line in natural habitats, although it is dominant and abundant in disturbed areas (Morrison 2002). Many alien ant species become agricultural pests by protecting crop-damaging arthropods and creating mounds in agricultural fields. Other aggressive alien ant species in the U.S. include: *Anoplolepis gracilipes* (Smith), *Paratrechina flavipes* (Smith), *Pheidole megacephala* (Fabricius), *Solenopsis geminata* (Fabricius), *Technomyrmex albipes* Smith, and *Wasmannia auropunctata* (Roger) (Wheeler 1929, McGlynn 1999, Trager 1984, Deyrup 1991, Trager 1991, Wetterer and Porter 2003, Wetterer 2005)

Some introduced ant species do not appear to displace native species or greatly disrupt native ant communities, and are predominately found in habitats altered by human activity. *Monomorium pharaonis* (Linnaeus) (Pharaoh ant) lives in dry, warm habitats, and a colony of these 1.5 mm-long ants can travel great distances in crates, luggage, or machinery. Such travel has resulted in this species' worldwide distribution. *Tetramorium caespitum* (Linnaeus) (pavement ant) forms large colonies and lives in pavement cracks and building foundations throughout the eastern U.S.

Stefan P. Cover first found *Vollenhovia emeryi* in the U.S. in 1986 while sampling for ants in Washington, D.C., and its presence in North America is briefly mentioned by Hölldobler and Wilson (1990). *Vollenhovia* spp. are generalists and are distributed throughout Asia and the Pacific Islands (Wheeler 1907, Bolton 1995, Terayama and Kinomura 1997). There are no known *Vollenhovia* species native to the Western Hemisphere. The behavior and natural history of *V. emeryi* is relatively unknown. In its native habitat, polygyne colonies nest in decaying wood in riparian forests, have reduced wings (brachypterous), and a high rate of gynandromorphy (a condition where part of the individual is female and the other part male). Monogyne colonies are found in upland areas, nest in wood, and have queens with fully-developed wings (macropterous) and infrequent gynandromorphy (Kubota 1984, Kinomura and Yamauchi 1994). Reproductives eclose in the fall and overwinter in their nests. Wheeler (1906) described taxonomic details and more recent work has focused on queen morphology and gynandromorphy (Kubota 1984; Kinomura and Yamauchi 1994).

We give the first record of this ant in Virginia, and describe previously unpublished records of *V. emeryi* in Maryland, Philadelphia, and Washington D.C. We include observations made on a captive *V. emeryi* colony. We hypothesize that *V. emeryi* is spreading along the riparian corridors of Washington, D.C., and suggest that gifts of Japanese cherry trees during the early 20th century may have resulted in the introduction of this ant into the U.S. on two separate occasions.

Materials and Methods

Study Sites.—*Dyke Marsh Preserve:* Dyke Marsh Preserve (DMP) is part of the George Washington Memorial Parkway (GWMP) in Fairfax County, Virginia. The GWMP is a national park bordering the west shore of the Potomac River. The DMP is 3.5 km long, 500 m wide at its widest point on an east-west transect, and located 15 km south of the Ronald Reagan Washington National Airport. The DMP has areas of flood-plain forests, open tidal freshwater marsh, and swamp forests (Johnston 2000; Barrows et al. 2005). All sampling sites were within the DMP flood-plain forest.

The flood-plain forest is dominated by *Liquidambar styraciflua* L. (sweetgum)

and a dense under story of *Lindera benzoin* (L.) Blume (spicebush) and *Viburnum molle* Michx. (smooth arrowwood). Other trees common in the forest include *Acer negundo* L. (boxelder), *Acer rubrum* L. (red maple), *Fraxinus americana* L. (white ash), *Liriodendron tulipifera* L. (tulip tree), *Nyssa sylvatica* Marshall (tupelo), *Quercus palustris* Münchh. (pin oak), *Quercus phellos* L. (willow oak), *Quercus rubra* L. (red oak), *Sassafras albidum* (Nutt.) Nees (sassafras), and *Ulmus americana* L. (american elm).

Fort Washington: Fort Washington National Park (FWNP) is located 20 km south of Washington, D.C. in Prince George's County, Maryland. The current structure dates to 1824, and previous forts on this site date to 1808. The park and surrounding area is greatly impacted by human activities. Trees species found around the park are *Quercus* sp., *L. styraciflua*, *U. americana, L. tulipifera, Platanus occidentalis* L. (eastern sycamore), and various *Prunus* cvs. (cherries). Open areas are dominated by grass and edge vegetation. Areas along the Potomac River are dominated by young *A. negundo* and *U. americana.* Most areas along the river were used as warfs and contain concrete, drift wood, and other beach debris.

Glen Echo Park: Glen Echo Park (GEP) is part of the GWMP on the Maryland side of the Potomac River 7 km north of Washington, D.C. The area has been used as an amusement park since the late 19th century. Currently the park is operated by the National Park Service for education and various family oriented activities. The forest around the GEP is second growth eastern deciduous and primarily consisting of *A. negundo, L. tulipifera, U. americana, P. occidentalis.*

Observatory Hill: Observatory Hill, on the Main Campus of Georgetown University, Washington, D.C., is adjacent to Glover-Archbold Park, part of Rock Creek Park (a national park). Observatory Hill is a manicured landscape with *Asimina triloba* (L.) Dunal (pawpaw), *Ilex* spp. (hollies), *Metasequoia glyptostroboides* Hu and W. C. Cheng (dawn redwood), *Prunus* cvs., *Quercus* spp. (oaks), *Robinia pseudoacacia* L. (black locust), and other trees.

Site Selection.—*Dyke Marsh Preserve:* As part of a larger study on the ant community of the DMP forest, 60 random sites were selected within the DMP using a geographical information system (ESRI Inc. 2001), the National Park Service's AlaskaPak extension (National Park Service 2002), and high-resolution aerial photography with the cooperation of the National Park Service GIS Coordinator of the GWMP. Sites were in a predefined area of the forest whose borders were at least 5 m from trails or roads. A Trimble™ backpack global positioning system (GPS) was used to locate each of the sites in the forest.

Fort Washington: Three areas within the FWNP were sampled during March through September, 2002; and during May and November, 2003. Sampling in the southeastern part of the park included open grass areas, young upland woods, gullies, and areas around and on Bunker B. Sampling in the western part of the park included public fishing areas near the shoreline and near the lighthouse. Sampling in the northeast of the park was done in wooded areas, picnic grounds, and along trails.

Glen Echo Park: Ant sampling in GEP occurred as part of a Bioblitz sponsored by the National Park Service, The Nature Conservancy, and the Virginia Museum of Natural History on June 24 and 25, 2006. Sampling was done along a short stretch of path leading down to a gully near the Clara Barton Parkway (38° 58′02″ N, 77° 08′47″ W).

Observatory Hill: A pitfall trap was placed on Observatory Hill in an open area below a large oak tree (*Quercus rubra* L.) and near a grove of small pawpaw (*A. triloba*) at 38° 54′28″ N, 77° 04′39″ W. The area was open with pieces of bricks and pavement, loose gravel, and grass.

Ant collection.—*Dyke Marsh Preserve:* Soil cores (70 × 70 mm) were collected from each site in the third week of June, August, and October in 2002 and 2003. Arthropods were extracted from the soil with the use of Berlese funnels. A single collar and funnel pitfall trap of the design described in Kjar and Barrows (2004) was used at each study site. The pitfall traps were run for 24 h, in the last week of June, August, and October during 2002 and 2003.

Fort Washington: Sites at FWNP were sampled using Berlese funnels, pitfall traps, and Winkler extraction (Suman 2004).

Glen Echo Park: Hand sampling was done for 30 minutes along the gully by turning over stones, searching tree limbs and leaf litter, and breaking up decomposing tree limbs and stumps.

Observatory Hill: A single pitfall trap of identical design to the DMP site was left for 48 h starting on 14 September 2004. Hand sampling near the pitfall trap location was performed 7 June 2005.

Ant Identification.—Ants were identified using Bolton (1994), Creighton (1950), the National Museum of Natural History ant collection, and verified by Dr. David R. Smith (USDA), and Mr. Terry P. Nuhn (USDA). Voucher specimens are in the arthropod collection of the Laboratory of Entomology and Biodiversity at Georgetown University, Washington, D.C. Specimens collected from Fort Washington National Park are deposited with the National Park Service under catalog number 13651 (Suman 2004).

Results

Ant Collection at the Dyke Marsh Preserve.—*Vollenhovia emeryi* was found at two locations in the DMP: site 33 (38° 46′27″N, 77° 03′01″ W); site 58 (38° 46′26″ N, 77° 03′01″ W). Workers were found in pitfall trap samples during both 2002 and 2003. One was collected in June of 2002, and another was collected August 2002, both at site 33. This site is dominated by the alien vine *Ampelopsis brevipedunculata* (Maxim.) Trautv. and is 15 m from the banks of the Potomac River. Other alien plants in this site include *Celastrus orbiculatus* Thunb. (Asian bittersweet), *Clematis terniflora* Dc. (Asian clematis), *Lonicera japonica* Thunb. (Japanese honeysuckle), and *Rosa multiflora* Thunb. (multiflora rose). The only native plant in site 33 was a small *Prunus serotina* Ehrh. (wild black cherry) seedling.

During August 2003, one worker was found in a pitfall sample from site 58, approximately 30 m south of site 33. Site 58 is 15 m from the river and located below a 132-cm-dbh *A. rubrum*, a 64-cm-dbh *L. styraciflua*, and a 51-cm-dbh *U. americana*. The plant community in this site was dominated by the alien vine *L. japonica*, and also contained *A. brevipedunculata*. Native plants in site 58 included all three tree species mentioned above and the monocot vine *Smilax rotundifolia* L. (greenbrier).

Ant Collection at Fort Washington.—Twenty-four workers of *V. emeryi* were found in FWNP on June 26, 2003. The ants were found in debris along the shore of the Potomac River near the lighthouse. A Berlese funnel was used to extract arthropods from the debris.

Ant Collection at Glen Echo Park.—One *V. emeryi* worker was collected by hand at the beginning of the trail surveyed. The worker was found on the surface of the leaf litter layer.

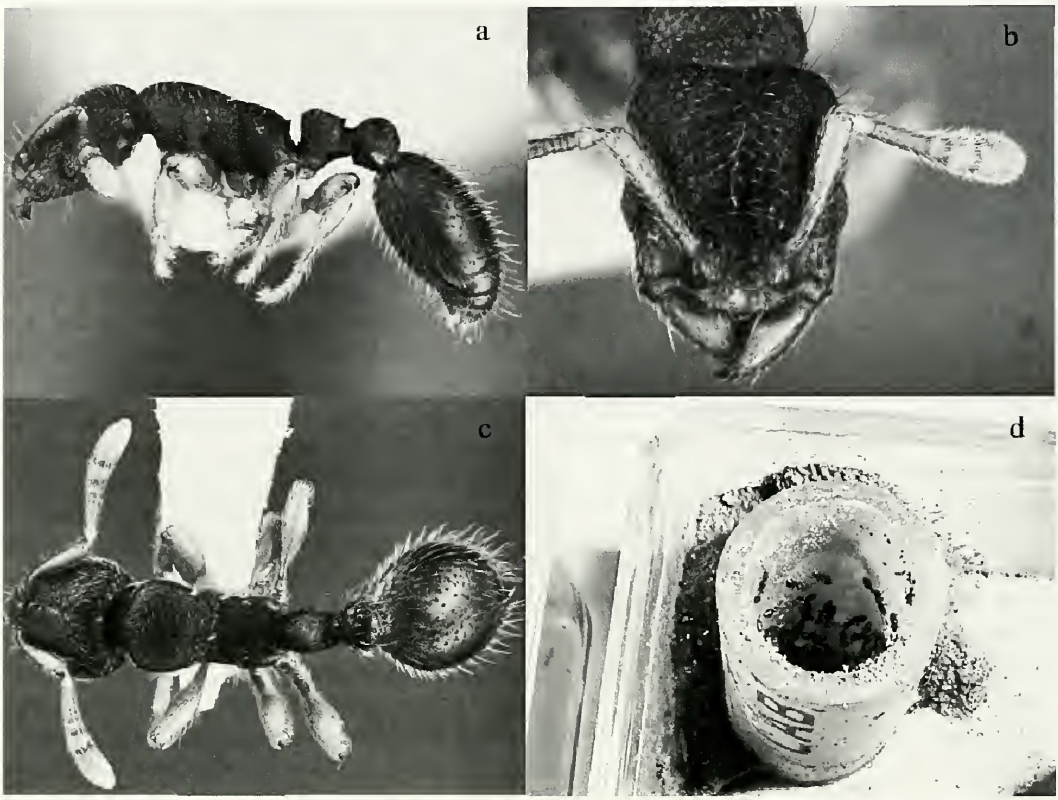

Fig. 1. Three images of a *V. emeryi* worker, and an image of the *V. emeryi* nest at the U.S. National Museum of Natural History. The frames are images of: a, profile view; b, head view; c. dorsal view; d. the nest of the colony taken from Observatory Hill, Georgetown University, Washington, D.C.

Ant Collection on Observatory Hill.—The 14 September 2004 pitfall-trap sample from Observatory Hill contained 10 *V. emeryi* workers along with several common ant species: *Camponotus pennsylvanicus* (De Geer), *Lasius alienus* (Foerster), and *Prenolepis imparis* (Say).

On 7 June 2005, a colony of *V. emeryi* was hand-collected from the same area of Observatory Hill. The colony had 28 workers, three dealate (queens that have lost their wings) females, five larvae, and 10 eggs. The colony's nest was located in soil mixed with bricks, gravel, and wood. The nest was 2 cm below the soil surface with slightly mounded soil around the opening.

Members of the colony collected from Observatory Hill were slow moving on a warm day. After the colony was disturbed, workers quickly moved all exposed eggs and larvae under soil or within the moistened paper used to transport them. When hand collected, workers attempted to move away from an aspirator and forceps and did not have the 'crouch-and-freeze' behavior of such small myrmicines as *Cyphomyrmex* spp. and *Temnothorax* spp. (Wheeler 1907, Cole 1940, Fellers 1987). If a worker was pushed onto her dorsal surface, she struggled to right herself. These ants have short legs with inflated femora, although they are relatively elongate for their small overall length of about 2.5 mm (Fig. 1). The 28 workers from the colony showed no readily visible variation in coloration or size.

The live colony was taken to Ted R. Schultz and Eugenia Okonski at the

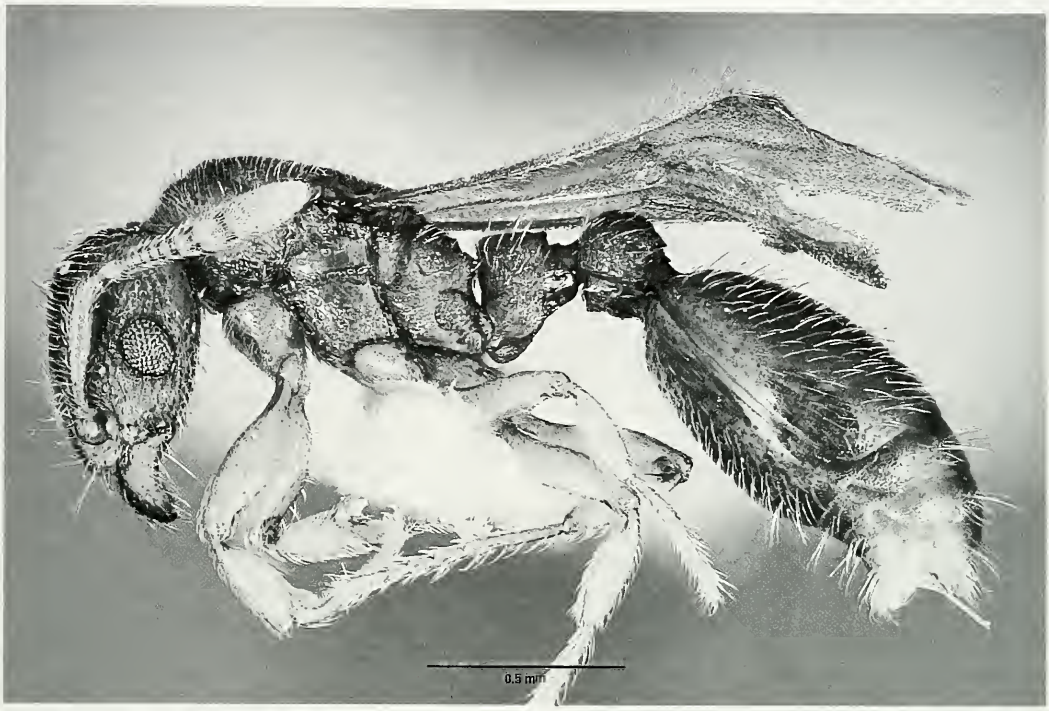

Fig. 2. Image of a brachypterous *V. emeryi* alate queen. This queen is from Stefan Cover's 1986 survey of Rock Creek Park, Washington, D.C. (Photograph used with permission of and taken by April Nobile, California Academy of Sciences, www.antweb.org).

National Museum of Natural History and Okonski is maintaining it at the Museum. After the colony was placed in the artificial habitat it moved its larvae, eggs, and queens into the small hose used to add water to the porous clay base of the nest container. Within two weeks the colony moved into the small gap between this hose and the plastic wall of the container, and built a small chamber with two openings from the small amount of soil that was introduced into the container with the colony (Fig. 1d). Foragers frequently enter and leave the chamber. Queens have not been observed outside of this chamber.

Discussion

Vollenhovia emeryi is a recently discovered alien myrmicine ant from Japan and may be spreading across the mid-Atlantic region of the U.S. This ant is native to Japan (30–45° N) (Wheeler 1906, Bolton 1995), and therefore may have little problem acclimating from southern Virginia north to southern New England along the U.S. East Coast.

The June 2002 collection in DMP is the first record of this ant in Virginia, and the June 2003 collection at FWNP is the first record of this ant in Maryland. The Observatory Hill collections (September 2004 and June 2005) are the second and third collections of this ant in the District of Columbia. Previous records of this ant include the first record of this ant in the U.S. from a 1986 survey of the ants of Rock Creek Park in Washington, D.C. (Hölldobler and Wilson 1990); and Philadelphia, Pennsylvania, in 1993 (King and Green 2005). The alate reproductive females found in the U.S. have reduced wings (brachypterous) (Fig. 2), and therefore mating flights, especially ones of any distance may not be possible. In view of this information,

it seems likely that *V. emeryi* was independently introduced into Philadelphia and Washington, D.C.

An intriguing hypothesis on the introduction of *V. emeryi* in the U.S. concerns the Japanese gift of cherry trees that were planted along the Tidal Basin by the Jefferson Memorial in Washington, D.C., and at Fairmont Park in Philadelphia. The first 2,000 trees intended for Washington, D.C. were imported in 1910. This first shipment was destroyed due to the numerous insects and other pests inhabiting them (National Park Service 2005). After the U.S. received a second gift of 3,020 cherry trees from Japan, the trees were planted in 1912. More cherry trees were planted in 1965 and 1986 around the Tidal Basin and the area around the Washington Monument (National Park Service 2001). The fact that Japan gave 2,000 cherry trees to Philadelphia in honor of the 150th anniversary (1926) of the U.S. Declaration of Independence provides further support to the cherry tree hypothesis.

Transport in the root balls of these trees would be ideal for ants with a wet nesting habitat preference. There were no exhaustive surveys of the District of Columbia's ant fauna after Theodore Pergande's (1840–1916) time at the National Museum of Natural History until Stefan Cover's work in the mid-1980s. This small ant could have easily spread throughout the Washington, D.C., area unnoticed during this 70-yr lapse of myrmecological survey data.

The potential ecological impact of this alien ant is entirely unknown. Cover's observations in Rock Creek Park did not reveal displacement of native ant species by this species, and few ant species in this area, with the exception of *Ponera pennsylvanica* Buckley, share this species' nesting preference of extremely hydric rotting wood. The location of *V. emeryi* at Georgetown University, a sunny southern slope under an oak tree approximately 1 km from the Potomac River, indicates that this species is not confined to wet habitats as previously thought, although the Georgetown colony at the National Museum of Natural History showed an obvious preference for an extremely moist nest location (Fig. 1d). The polygynous nest from an upland dry area suggests the habitat range of polygyne colonies in the introduced population should be investigated, as it may differ from what has been reported for this species in Japan.

Long-distance dispersal by wind is unlikely in this epigaeic ant with putatively brachypterous reproductives. The presence of this ant in the DMP forest and Fort Washington National Park is probably the result of its rafting in wood. This ant's preference for wet rotting wood may result in queens' founding nests in wood that has been left when tides go out and picked up again and moved down river during subsequent high tides. Most flooding events would send *V. emeryi* from the City downstream to DMP and FWNP with the exception of hurricane associated storm surges. However, the Potomac River is tidal in the Washington, D.C., Area and therefore they could raft up and down the river depending on conditions. However, the GEP record of *V. emeryi* 7 km north of the city adds support to a gradual spread and an early introduction.

Vollenhovia emeryi was found in moist stream bottoms in Rock Creek Park. Rock Creek empties into the Potomac River 2 km upstream of the Tidal Basin. It is possible that *V. emeryi* traveled along the river banks and the Chesapeake and Ohio Canal spreading throughout Rock Creek Park, Georgetown University, and GEP which are all connected directly to the river and canal by forested park land. Human introduction of *V. emeryi* to each of the five Washington, D.C., area loca-

tions is possible, but the apparently restricted regional distribution of this ant species suggests that it had a single introduction in this city and another in Philadelphia. If this species were commonly introduced by humans through agricultural or horticultural products, it likely would have come to the attention of myrmecologists sooner and have a much wider known distribution. *Vollenhovia emeryi* is not a cryptic ant species and is morphologically distinct from other ant species in the eastern U.S., and areas around the Mid-Atlantic Region have been extensively studied for decades by myrmecologists.

Conclusions

Vollenhovia emeryi is present in at least two locations in the DMP forest. It has also been found in a national park within Washington, D.C., and in three locations within two national parks along the Potomac River in both Maryland and Virginia, and may be common along riparian water ways in the Mid-Atlantic Region. It appears likely that this species was introduced in the early 20th century in Washington, D.C. and Philadelphia through the import of Japanese cherry trees. If the trees are the vehicle of introduction, other cities in the U.S. with suitable nesting areas may also have this alien ant due to the popularity of such cherry trees. The impact of *V. emeryi* on local ant communities is unknown, but its preference for extremely wet nesting sites, and lack of a painful sting, this ant's effect on most native biota and humans may be low. However, to verify that this ant will not become destructive to the eastern riparian forest biota, the ecology and behavior of *V. emeryi* in the U.S. and Japan should be examined in depth.

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